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Effect of S and B on the yield, yield attributes and protein content of aromatic rice

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Abstract: A field experiment was conducted at the Central Farm of Bangladesh Agricultural University, Mymensingh, during the period from July to December, 2007 to observe the effect of S and B fertilization on the yield attributes and yield of aromatic rice cv. *Kalizira.* The experiment comprised of four levels of S and three levels of B viz. 0, 10, 20, and 50 kg S ha^{-1} (S_0, S_{10}, S_{20} and S_{50}) and 0, 2 and 4 kg B ha^{-1} (B_0, B_2 and B_4), respectively. The experiment was laid out in a completely randomized block design (RCBD) with three replications. Yield and yield attributes were significantly influenced by the individual application of S and B except plant height and panicle length. The highest values of most the parameters were recorded from the plot fertilized with S_{20} and B_2. Interaction effect of S and B fertilizer showed significant variation on filled grains, total grains, 1000-grain weight, grain and straw yield. The highest values of most of the parameters were obtained from the treatment combination of S_{20} B_2 except plant height, panicle length, total tillers, straw nitrogen content and straw yield which were highest in the treatment combinations of S_{10} B_0, S_{10} B_2, S_{10} B_4, $S_{20}B_4$ and S_{10} B_4, respectively. The overall results thus suggest that aromatic rice can be grown in non calcareous soil fertilized with 20 kg S in combination with 2 kg B ha^{-1} to get higher yield for its large scale production in Bangladesh.
Key words: Sulphur, boron, aromatic rice, yield, protein.

Introduction

Bangladesh is an agrarian country where agriculture is the single largest sector of her economy. Rice is the staple food for more than three billion people that is over half of the world's population. Rice contributes 91.1% of the total grain production and covers 74% of the total calorie intake of this countries people. According to (BBS, 2004) Bangladesh produces 26.19 million tons rice per annum from 10.83 million hectares of lands. But the yield of rice is quite lower (3.43 t ha^{-1}) compared to other rice producing countries of the world such as Australia, Korea, Japan and Spain where per hectare yield are 10.29, 5.99, 5.85 and 7.28 ton, respectively. There are two types of transplant aman rice in Bangladesh viz. course and fine rice. Among these two, most of the fine rice is aromatic. Some of these have very nice quality i.e. fineness, aroma, test, protein contents etc. Aromatic rice are generally low yielding but they are considered best in quality and also considered highly valued and cultivation of aromatic rice becoming popular day by day due to its high price and export potential. Aromatic rice is now an important commodity in international trade having small grain with pleasant aroma. Islam *et al.* (1996) observed that the yield of aromatic rice was lower (1.5 - 2.0 t ha^{-1}) but its higher price and low cost of cultivation generated higher profit margins compared to other varieties grown in the area. Recently S and B deficiencies have found to be spread wide in soils of Bangladesh and crop response to S and B appears to be progressively prominent (Mondal, *et al.*, 1992). Now-a-days S is considered as the primary macro nutrient elements and its requirement in different crops increases in the order oilseed>pulses>cereals (Kawsar, *et al.,* 1991). Removal of S by crops from the soil increases S deficiency throughout Bangladesh. Sulphur is the constituent of organic matter and also involves in many biochemical processes. Approximately, 1 million hectare of cultivable land in Bangladesh is suspected to have B deficiency problem (Ahmed and Hossain, 1997). It is involved in the synthesis and metabolism of protein. Protein content of grain is markedly improved due to application of S and B (Jahiruddin, *et al.,* 1994). Sulphur and boron stress may interrupt the synthesis of nitrate reductase enzyme, which is important for the production of protein as well as yield and quality of grain. A very few sporadic research works have been done on the effect of S and/or B on the yield and yield components of aromatic rice. Considering the above facts, the present piece of study was undertaken to examine the effect of S and B on the yield attributes, yield and protein content of aromatic rice.

Materials and Methods

A field experiment was conducted during *Kharif* season to examine the effect of S and B on yield attributes and yield of aromatic rice in the central farm of Bangladesh Agricultural University, Mymensingh, during the period from July to December, 2007. The soil was silt loam in texture having pH 6.7 with 1.17% organic matter, 0.09% total N, 11.50 mg kg^{-1} available P, 0.06 cmol kg^{-1} exchangeable K. The experiment consisted of S and B 0, 10, 20, 50 and 0, 2, 4 kg ha^{-1} respectively. Soil samples were randomly collected at 0-15 cm depth during the time of land preparation from twenty five spots of the experimental land and composited. The crop under study was indigenous aromatic rice (cv. *Kalizira*). This rice genotype was characterized by its scented properties like aroma, size and taste. Sulphur and B fertilizers were applied as per design and treatments from gypsum and borax and all other fertilizers like urea, triple super phosphate, and muriate of potash were applied according to the fertilizer recommendation guide. All chemical fertilizers and one-third of urea were applied during final land preparation and rest of the urea were applied in two instalments. The experiment was laid out in RCBD with three replications. The treatments were randomly distributed to the plots. Individual plot size (4 m x 2.5 m) 10 m^2, space between unit plots is 0.5 m and space between replication is 1m. Intercultural operations like weeding, thinning, gap filling, irrigation, pest control were done as and when necessary to ensure normal growth of crop. After collecting plant samples, the crop was harvested and sun dried for 3-4 days and grains were separated from the plants by beating the bundles with bamboo sticks. The seeds were dried in the sun for 2-3 days to 9% moisture level and cleaned. Soil and plant chemical properties were analyzed following the standard methods (Page *et al*., 1982). Analysis of variance was done with the help of computer package MSTATC developed by Russel (1986) and the mean differences of the treatments were adjudged by LSD test. Total nitrogen was determined by Kjeldahl method (Page *et al.*, 1982). Protein was calculated from percent total nitrogen multiplied by 5.85.

Results and Discussion

Plant height: The plant height of the experimental crop with different S levels failed to show any significant effect (Table 1). The above results obtained in the study are in conformity with the results of Verma *et al.* (2001). Variation in plant height was found to be significant (p<0.05) due to B fertilization (Table 2). The tallest plant (127.01 cm) produced where no boron fertilizer was applied (Table 2). The shortest plant (122.72 cm) was found when the crop received with 4 kg B ha^{-1}. Crop responses to S and B interaction for plant height were presented in Table 3. It can be observed that the interaction of S and B levels failed to show any significant effect on plant height. Numerically, the tallest plant was found when the crop was fertilized with 10 kg S + 0 kg B ha^{-1} and the shortest was found when the crop was fertilized with 0 kg S + 0 kg B ha^{-1}.

Table 1. Effect of S on the yield attributes, yield and protein content of aromatic rice cv. *Kalizira*

Treatments	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}	Total tillers hill^{-1}	Filled grains panicle^{-1}	Total grains panicle^{-1}	1000-grain weight (g)	Protein content (%)	
								Grain	Straw
S_0	123.11	21.35	11.00	13.22	158.33	179.33	10.80	6.96	3.33
S_{10}	125.97	24.22	12.11	14.33	187.11	203.78	11.07	7.43	3.69
S_{20}	125.69	24.59	13.33	14.44	209.78	225.22	11.36	7.72	3.86
S_{50}	122.80	24.25	12.89	14.67	193.33	212.67	11.32	7.72	3.69
LSD (0.05)	4.09	3.53	1.15	3.17	8.32	13.62	0.09	0.04	0.04
CV (%)	3.36	29	9.49	20.89	4.55	6.80	1.79	3.73	6.62

Panicle length: The effect of S failed to show any significant effect on panicle length (Table1). The longest panicle (24.59 cm) was obtained from S_{20} and the shortest (21.35 cm) from control. Among the treatments 2 kg B ha^{-1} produced the longest panicle (24.60 cm) and the shortest from the control (Table 2). It was useful fact that crops fertilized with B might receive the added plant nutrient and that is why the panicle length was higher compared to control. The results confirms with the findings of Singh *et al.* (1997) who reported that application of B resulted higher panicle length. According to Table 3, it is noted that there was no significant difference in panicle length of aromatic rice due to S and B interaction. The longest panicle (26.17 cm) was recorded in 10 kg S + 2 kg B ha^{-1} and the shortest was recorded from 0 kg S + 4 kg B ha^{-1}.

Table 2. Effect of B on the yield attributes, yield and protein content of aromatic rice cv. *kalizira*

Treatments	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}	Total tillers hill^{-1}	Filled grains panicle^{-1}	Total grains panicle^{-1}	1000-grain weight (g)	Protein content (%)	
								Grain	Straw
B_0	122.72	23.10	10.33	12.08	163.25	186.25	10.73	6.67	3.28
B_2	123.44	24.60	13.67	15.00	202.17	219.50	11.35	7.89	3.86
B_4	127.01	23.11	13.00	15.42	196.00	210.00	11.34	7.78	3.74
LSD (0.05)	3.54	3.06	0.99	2.74	7.20	11.80	0.08	0.04	0.04
CV (%)	3.36	15.29	9.49	20.89	4.55	6.80	1.79	3.73	6.62

Total tillers hill^{-1}: The effect of S failed to show any significant difference on the number of total tillers hill^{-1} (Table 1). The data show that S_{50} treatment produced the highest (14.67) and S_0 treatment the lowest (13.22) total tillers hill^{-1}. It is revealed from the results that S enhanced the number of total tillers hill^{-1}. Chowdhury *et al.* (1995) also reported that number of total tillers hill^{-1} of rice was increased by S application. Variation in total tillers hill^{-1} was found to be significant (p<0.05) due to B application (Table 2). Application of 4 kg B ha^{-1} (B_4) produced the highest total tillers hill^{-1}. On the other hand, the lowest total tillers hill^{-1} was found in control treatment. B_2 treatment was statistically similar with B_4 (Table 2). The interaction effect of S and B failed to show any significant effect on total tillers hill^{-1}. The highest number of total tillers was found from the treatment combination of $S_{10}B_4$ (17.00 cm) treatment and the lowest (11.67 cm) from the control combination.

Effective tillers hill^{-1}: Effective tiller differs significantly due to the different levels of S application. The highest number of effective tiller (13.33) was observed when the crop was fertilized with 20 kg S ha^{-1} and the lowest was attained in control. It can be concluded from the above findings that increase in S levels caused considerable increase in effective tiller. Significant variation in effective tiller hill^{-1} was found (p<0.01) due to B application. Crop grown with 2 kg B ha^{-1} produced the highest number of effective tiller hill^{-1} (13.67) which was statistically identical with B_4 and control treatment produced the lowest (10.33) (Table 2). Singh *et al.* (1997), Sahu *et al.* (1995), conclusively suggested that application of B increased effective tiller hill^{-1}. The interaction effect of S and B failed to show any significant difference on effective tiller hill^{-1}. Table 3 shows that numerically the highest effective tiller was 15.67 and the lowest was 9.00

by 20 kg S + 2 kg B, 50 kg S + 2 kg B ha^{-1} and control treatments, respectively.

Filled grains panicle^{-1}: Variation in filled grains panicle^{-1} was found significant due to S application (Table 1). Sulphur @ 20 kg ha^{-1} gave highest filled grains panicle^{-1} (209.78) and control treatment produced the lowest (158.33). The result shows that higher filled grain mainly due to S fertilization. The present study is in accordance with the findings of Jahiruddin *et al.* (1994) who reported that filled grain of rice increased significantly due to increased levels of S. Data recorded in Table 2 shows that B significantly enhanced the filled grains panicle^{-1}. The highest value (202.17) was found when crop was fertilized with 2 kg B ha^{-1} and control treatment produced the lowest (163.25). Control treatment produced the lowest number of filled grains panicle^{-1} indicating that grains development was restricted by a shortage of B (Tisdale *et al*., 1999). The interaction effect of S and B was significant for filled grains panicle^{-1} (Table 3).The highest filled grains panicle^{-1} (231.00) was observed when the plot was fertilized with 20 kg S in combination with 2 kg B and the lowest value (152.00) from control combination. From this above findings, it is concluded that both S and B promotes the filled grains panicle^{-1}.

Table 3. Interaction effect of S and B on the yield attributes yield and protein content of aromatic rice cv. *Kalizira*

Treatments	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}	Total tillers hill^{-1}	Filled grains panicle^{-1}	Total grains panicle^{-1}	1000-grain weight (g)	Protein content (%)	
								Grain	Straw
$S_0 B_0$	125.50	22.50	9.00	11.67	152.00	176.00	10.50	6.55	2.93
$S_0 B_2$	123.70	21.25	12.00	14.00	161.00	183.00	10.80	7.02	3.28
$S_0 B_4$	120.12	20.30	12.00	14.00	162.00	179.00	11.10	7.31	3.74
$S_{10} B_0$	129.60	23.60	10.00	12.00	160.33	174.33	10.65	6.73	3.16
$S_{10} B_2$	124.71	26.17	13.00	14.00	213.67	234.00	11.30	7.89	4.04
$S_{10} B_4$	123.60	22.90	13.33	17.00	187.33	203.00	11.25	7.61	3.80
$S_{20} B_0$	128.75	24.20	11.33	12.67	177.67	201.67	10.86	6.79	3.80
$S_{20} B_2$	123.59	25.78	15.67	16.00	231.00	245.00	11.83	8.48	4.27
$S_{20} B_4$	124.73	23.80	13.00	14.67	220.67	229.00	11.40	7.89	3.45
$S_{50} B_0$	124.20	22.10	11.00	12.00	163.00	193.00	10.90	6.67	3.16
$S_{50} B_2$	121.77	25.20	14.00	16.00	203.00	216.00	11.45	8.19	3.92
$S_{50} B_4$	122.43	25.45	13.67	16.00	214.00	229.00	11.60	8.25	4.04
LSD (0.05)	7.086	6.11	1.98	5.49	14.40	23.60	0.15	0.08	0.08
CV (%)	3.36	15.29	9.49	20.89	4.55	6.80	1.79	3.73	6.62

Total grains panicle^{-1}: Variation in total grains panicle^{-1} was found to be significant due to S application (Table1.1). The highest total grains (225.22) were obtained from 20 kg S and the lowest (179.33) from control. The present study are in accordance with the findings of Islam *et al.* (1996), who reported that total grains of rice increased significantly due to increased levels of S. B significantly enhanced the total grains panicle^{-1} (Table 2) . The highest total grains panicle^{-1} (219.50) was found from 2 kg B ha^{-1} and the lowest (186.25) from control. Control treatment produced the lowest number of total grains panicle^{-1} indicating that total grains development was restricted by a shortage of B (Tisdale *et al*., 1999). The interaction effect of S and B was significant for total grains panicle^{-1} (Table 3). The highest total grains panicle^{-1} (245.00) was observed with 20 kg S in combination with 2 kg B and the lowest value (174.33) from $S_{10} B_0$ treatment. From this above findings, it is concluded that both S and B promotes the total grains panicle^{-1}.

1000-grain weight: It is revealed from Table 1 that 1000-grain weight was significant at different S levels. The heaviest grain was achieved when the crop provided with 20 kg S ha^{-1} and the lightest grain was recorded in control. The present result indicates that 1000-grain weight was influenced by S. 1000 grain weight of rice was significantly increased by S (Chowdhury *et al.* 1995). It is found from the Table 2 that 2 kg B ha^{-1} and control obtained heaviest and lightest grain weight, respectively. From the above findings it is evident that B promotes the 1000-grain weight. Jahiruddin *et al.* (1994) reported that 1000-grain weight of rice was significantly increased by B.1000-grain weight was statistically significant by B fertilization. The treatment combination of S and B interaction show significant effect on 1000-grain weight. Data recorded in Table 3 shows that the heaviest grain (11.83 g) was found by 20 kg S in combination with 2 kg B ha^{-1} and lightest grain (10.50 g) from control combination. From the present record it is clear that 1000-grain weight was influenced by S and B interaction.

Grain yield: Grain yield showed a significant variation for different S levels (Fig. 1). Among the treatment 20 kg S ha^{-1} produced the highest grain yield (2410 kg ha^{-1}) and the lowest (1910 kg ha^{-1}) from the control. Higher grain yield in S_{20} might have resulted from the cumulative favourable effect of the number of effective tillers hill^{-1}, filled grains panicle^{-1} and 1000-grain weight and also helps plant metabolism which produced higher yield (Tiwari *et al*., 1997). The result obtained in this regard is in accordance with the findings of Chowdhury *et al.* (1995) who reported that S increased the grain yield in rice. Boron showed a significant variation on grain yield. It is obtained from the Fig. 2 which shows that grain yield was the highest (2410 kg ha^{-1}) when the crop received 2 kg B ha^{-1} and the lowest (1960 kg ha^{-1}) was found from control. This might be due to B deficiency which helps seed formation (Brady, 1996). Present results are consistent with that of Wankhade (1998) reported that grain yield increased significantly with each increment of B. Fig. 2 also notices that interaction of S and B was significant regarding grain yield. The highest grain yield (2830 kg ha^{-1}) was recorded in 20 kg S in combination with 2 kg B ha^{-1} and the lowest (1840 kg ha^{-1}) from control. The second highest yield (2620 kg ha^{-1}) was found with the combination of 50 kg S and 4 kg B ha^{-1}. It is clear from the above trial that S in conjunction with B produces high grain yield. Similar opinion was on put forward by Ahmed *et al*. (1997) reported that S in combination of B produced higher grain yield.

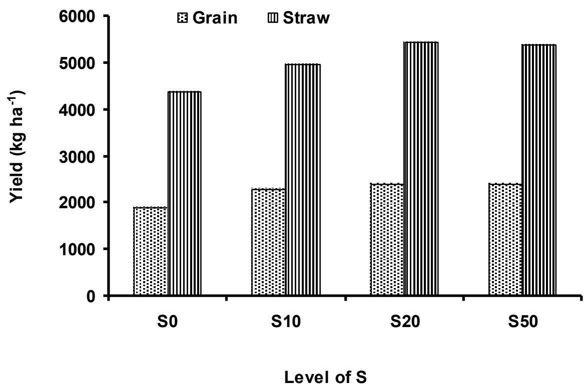

Fig. 1. Effect of S on grain and straw yield of aromatic rice cv. *Kalizira*

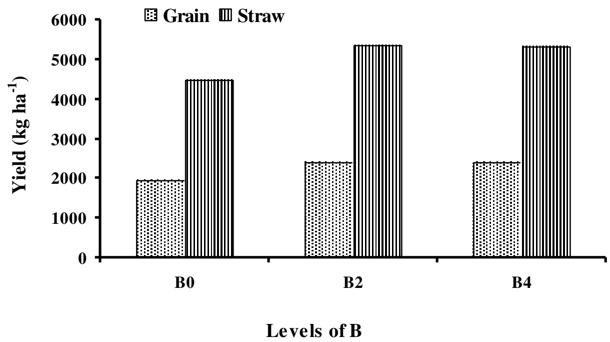

Fig. 2. Effect of B on grain and straw yield of aromatic rice. cv. *Kalizira*

Straw yield: Different levels of S on straw yield were also showed the same trend as did the grain yield (Fig. 1.). The production of higher straw yield (5430 kg ha^{-1}) in 20 kg S ha^{-1} might be due to the fact that S tends primarily to encourage above ground vegetative growth and lower (4370 kg ha^{-1}) was found from the control. The findings for these characters agree with the result obtained by Singh *et al*. (1997) who observed that straw yields of mustard increased with increase in S rates. Fig. 2 showed that straw yield was significantly influenced by B application. The highest and lowest straw yields were obtained from B. Fig 3 also notices that interaction of S and B was significant regarding straw yield. The highest straw yield (6070 kg ha^{-1}) was recorded in 10 kg S in combination with 4 kg B ha^{-1} and the lowest (3840 kg ha^{-1}) was found from $S_{10}B_0$ and control. The second highest yield (5800 kg ha^{-1}) was found with the combination of 20 kg S and 2 kg B ha^{-1}. It is clear from the above trial that S in conjunction with B produces high straw yield. From the discussion, it is clear that 10 kg S in combination with 4 kg B ha^{-1} had the best performance for straw yield.

Grain protein content: Effect of S on protein content in grain was statistically significant (Table 1). It was found that S application increased the protein content in grain. The highest protein content (7.72%) was obtained from S_{20} and S_{50} and the lowest (6.96%) from control. The effect of B on protein content in grain was significant (Table 2). The protein content in rice grain was highest (7.89%) at B_2 treatment and was lowest (6.67%) in control treatment. The data revealed that the interaction effect of S and B was statistically significant (Table 3). The combined application of S and B increased the protein content in an irregular pattern. The highest protein content (8.48%) was achieved by 20 kg S ha^{-1} + 2 kg B ha^{-1} and the lowest (6.55%) was in control combination.

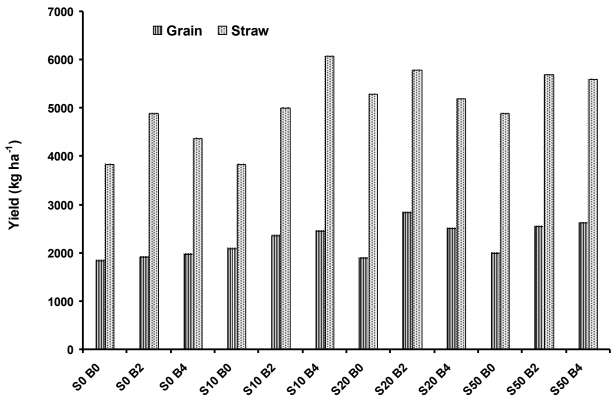

Fig. 3. Interaction effect of sulphur and boron on the grain and straw yield of aromatic rice cv. *Kalizira*

Straw protein content: Sulphur treatment shows significant effect on protein content of straw. The highest protein content (3.86%) was obtained from S_{20} and lowest (3.33%) from control. Effect of B on protein content in straw was significant. Among the treatments, the highest protein content (3.86%) was observed due to the application of B at the rate of 2 kg ha^{-1} and the lowest (3.28%) was in control treatment (Table 2). The treatment combination of S and B had significant variation on protein content of the straw of rice. Table 3 shows that highest protein content (4.27%) was achieved by 20 kg S+ 4 kg B ha^{-1} and the lowest (2.93%) was found from control combination.

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